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UNITED STATES PATENT APPLICATION

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for

<u>EMULATOR</u>

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Title Of Invention

EMULATOR

Cross-Reference To Related Applications

This application claims priority of German patent applications DE10021836.9 and DE10021835.0 filed on May 6, 2000 and DE10033820.8 filed on July 12, 2000.

Field Of The Invention

The invention concerns a system for producing a presettable polarization mode dispersion (PMD) according to the general sense of Patent Claim 1.

Such systems are necessary, for instance, to produce a certain PMD for measuring or test systems or to compensate PMD-induced distortions in optical transmission systems and particularly transmission fibers.

Because every glass fiber is unintentionally double-refractive to some degree, light signals of various polarization run through glass fiber at diverse collective speeds. Therefore, light particles of diverse polarization reach the receiver at different times with respect to one another; this running time effect results in a broadening of the received signal and thus a reduction of transmission quality. In particular, this can lead to a rise in bit error rates.

Polarization mode dispersion includes all polarization-dependent running time effects, in which the signal spreading can be fully described by the dispersion behavior of two mutually independent, orthogonally related

polarization modes. Because double refraction is constantly changing through external influences such as temperature and mechanical load, and in addition depends on the wavelength; there is permanent variation both in the position of the principal states of polarization (PSP) and in the running time difference between the PSPs. This is referred to also as second-degree polarization mode dispersion.

The result of the aforementioned effects is a time-fluctuating wavelength-dependent PMD behavior with time constants on the order of minutes.

Background Of The Invention

A familiar system, which is taken as a point of departure in the formulation of the general sense of Patent Claim 1, includes an initial polarization splitter/combiner element, which splits the oncoming signal into two signals with mutually perpendicular polarization directions; a delaying unit, which is installed in one of the signal paths of the two (split) signals; and a second polarization splitter/combiner element, which reunites the two severed signals.

This familiar system has the disadvantage that it allows only the compensation of first-degree PMD-induced distortions. However, it is precisely in long transmission paths that second-degree PMD-induced distortions play a considerable role.

Another known system for PMD emulation is, for instance, a system of PM fibers with various or equal group running times, on which a polarization transformation unit is superposed in each case.

Summary Of The Invention

The invention is based on the objective of providing a system to produce a preestablished polarization mode dispersion, which also allows the production of a second-degree polarization mode dispersion, and which matches the PMD of a real transmission fiber as exactly as possible.

A solution of this objective according to the invention is indicated in Patent Claim 1. Refinements of the invention are the subject of Claim 2, which follows.

According to the invention, in order to produce a polarization mode dispersion that corresponds to the second-degree PMD of a real fiber, the basis is a system according to the introductory statement; this generic system is further refined in that an element is foreseen which twists the polarization main axis before and behind the element by an appropriate angle to one another. The light signal emitted from this element is, according to the invention, fed into a system which also consists of a polarization splitter/combiner element, a delaying path, and another polarization splitter/combiner element to bring the two signal paths together. With this system, in addition to the production of a first-degree polarization mode dispersion, it is also possible to produce a second-degree dispersion. It is especially advantageous that --on the basis of a system according to the general sense of patent Claim 1--it is not even necessary to use additional components, which would increase the costs. Instead it is possible to produce a first-degree polarization mode dispersion because the unused input connection of the second polarization splitter/combiner element serves as input connection for the signal. This signal then runs through the delaying path and the first polarization ray divider in the opposite direction to the oncoming signal. At the fourth gate of the first polarization splitter/combiner element, this signal is then uncoupled. The uncoupled signal then shows the desired first- and second-degree polarization mode dispersion.

It is a particular advantage of this system that in order to produce the second-degree PMD, only a single control value, namely the length of the delaying path, must be preset.

It is also preferable, if the angle by which the element twists the polarization main axes with respect to one another, can be entered. It is thereby possible to enter the steepness of the principal state of polarization (PSP) as well as the proportion of the first- and second-degree polarization mode dispersion

(PMD). It has proven particularly useful to select an angle of about 22.5 degrees. With such an angle, the statistical proportion between first- and second-degree PMD can be practically completely adapted to the angle of a real transmission fiber in the optic network.

The most varied known solutions can be applied as delaying paths. For example, it is possible for the delaying path to be produced optically or electrically. In the case of an optical realization, the beam in the delaying path is emitted as a free beam. To adjust the delay, it is necessary to alter the path length over which the beam is emitted as a free beam.

In a further realization of the delaying path, the fibers are exposed to mechanical forces so that the optical parameters of the fibers are modified.

The adjustment of the angle by which the main axes are bent toward or away from one another, can also proceed in various ways:

For instance it is possible that, in order to adjust the angle, two PM fibers are spliced together at an angle corresponding to the angle to be adjusted. It is also possible to adjust the angle by use optical slip rings and/or wave plates.

A whole range of elements, all commercially available, can be employed as polarization splitter/combiner elements. For instance, the elements can be executed as PBS cubes or as all-in-fiber elements.

In every case, however, it is preferable if all light paths are polarization receivers. This can be achieved, for instance, if free-beam paths and/or PM fibers form the light paths.

Brief Description Of The Drawings

The invention is illustrated in greater detail below by means of an example with reference to the illustration. The illustration is as follows:

Figure 1 The theoretical structure of a system according to the invention to produce a presettable polarization mode dispersion.

Detailed Description Of The Drawings

Figure 1 shows a system according to the invention, which presents an initial polarization splitter/combiner element (1), at whose connection (11) the incoming light signal arrives. The element (1), in particular, can be a polarization splitter/combiner element, a PBS cube, or an all-in-fiber element. The element (1) splits the incoming signal into two signals with vertical polarization alignment to one another. In the first signal path (21), a delaying unit (23) is installed, which delays the corresponding light signal by an appropriate value. In the other signal path (22) there is no delaying element. A second polarization splitter/combiner element (3), which is reached at its connections (31, 32) by both light signals, brings the delayed and the non-delayed signals back together. The reunited signal exits at the connection (33) of the element (3). To this extent, the structure is known and serves to compensate a first-order polarization mode dispersion.

To produce a second-order polarization mode dispersion, an element (4) is foreseen, which is contacted by the signal exiting from the connection (33), and which twists the polarization main axes before and behind the element by an appropriate angle to one another. This angle can in particular be 22.5 degrees. The light signal emerging from the element (4), whose polarization main axes are twisted by the aforesaid angle, contacts the connection (34) of the element (3).

The element (3) splits the signal arriving at its connection (34) in such a way that it is led back by way of the signal paths (31, 32) again to the element (1).

The polarization splitter/combiner element (1) leads both signals together, the reunited signal exits from the element (1) at the connection (14), where it is transformed in such a way that it compensates a first- and second-order polarization mode dispersion.

In the foregoing the invention has been described by means of an example without applicability and feasibility being considered. It goes without saying that a whole range of transformations are possible. It is possible, for instance, that the angle by which the element twists the polarization main axes against one another is adjustable. To adjust the angle, two PM fibers can be spliced together at an angle corresponding to the angle to be adjusted. As another means of adjusting the angle, optical slip rings and/or oblique-standing wave plates can be used.